CHAPTER I

INTRODUCTION

The discovery of the radio emission from celestial objects in 1931 opened the door to a completely new perspective on the universe for human understanding. Before that day, purely visual techniques were used to study the universe. By the aid of optical telescopes invented in the early seventeenth century and photographic techniques in the last century, the knowledge of the universe came from observations in the visible part of electromagnetic spectrum.

For ground-based observation, there are two transparent bands of the Earth's atmosphere and ionosphere for electromagnetic energy from space. The graph in Fig.1.1 shows the position of the optical and radio window in electromagnetic wave energies to the Earth.

We can see that the radio window is much boarder than the optical window. The optical window extends from about 0.4 to 0.8 microns (about 1 octave) and the radio window extends from about 1 cm. to 10 m. (about 10 octaves). The limits of the transparency to radio waves from celestial bodies depends on the absorption of the atmospheric molecules in the high frequency part and the electron density of the ionosphere in the lower part (Kraus, 1986). The density of electrons in the ionosphere is a function of the time of day, solar activity, etc.

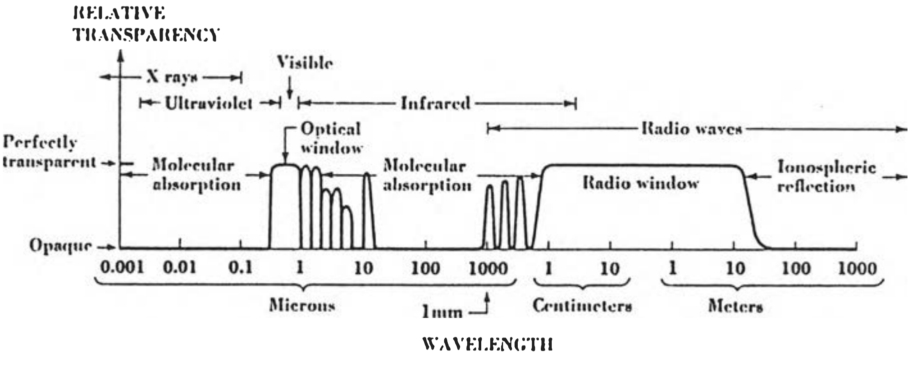

Fig.1.1 The transparency of the Earth's atmosphere for the electromagnetic energy (Kraus, 1986).

The observations in various parts of the spectrum bring more complete information on our universe. There are many objects which have relatively strong emission radio frequencies but are faint optically, especially the objects from the greatest measured distances beyond the range of ground-based optical telescopes. Because the radio photons are of much lower energy than optical photons, there are larger numbers for the same energy radiated. Observation at the greatest possible distance are essential to modern astronomy since they bring the knowledge of both the origin and type of the universe in which we live. As the late Carl Sagan said, they may tell us the ultimate destiny of the human race.

The Early Years of Radio Astronomy

In 1931, Karl G. Jansky, a radio engineer of Bell Telephone Laboratory at Holmdel, New Jersey had been assigned to study the direction of arrival of thunderstorms static, in relation to transoceanic radio-telephone communication. If the direction was found, it might be possible to design an antenna system to minimize response in this direction. His system operated at a frequency of 20.5 MHz and use a unidirectional antenna rotating 20 min./revolution.

Jansky reported the first results in 1932. He was able to identify three group of statistically noise. The first two types came from local and distant thunderstorms and the last type was identified with an origin from the center of the Milky Way. The last type of static noise was first discovered in January, 1932. Accordingly the science of radio astronomy was founded at this time.

Further observations lead to the conclusion that the source of this radiation is located in stars or in the interstellar matter which is distributed throughout the Milky Way. Jansky noted that if a star was the source, strong radiation should be detected from the Sun, whereas at no time had he detected any solar radiation. His conclusion that ordinary stars are not important source of galactic radiation was correct. However, he would have detected the signal from the Sun, if he had continued his observations for a few more years. Jansky was well aware of the astronomical importance of his observation. He proposed the construction of a larger antenna but he obtained no support for his proposal.

In 1937, Grote Reber in Illinois became interest in Jansky's work and constructed a parabolic-reflector antenna of 31 ft. at his home. By the spring of 1939, he could indicate the radiation in the plane of ours galaxy at frequency 160 MHz. Although his antenna was smaller than Jansky he used a much shorter wavelength, his antenna beam was considerably sharper. Reber's antenna had a conical beam about 12° between half-power points while Jansky's beam was fan-shaped with a half-power width of about 30° in the narrower direction.

Reber published his first maps of the radio sky in 1944, the maps are the first extensive quantitative measurement of radio radiation from the sky. After this time there were discoveries the neutral hydrogen emission line in 21.1 cm wavelength by Ewen and Percell of Harvard university, by Muller and Oort of Lieden, and Christiansen of Sydney in 1951. Hydrogen is the most common element in the universe.

Observations in radio wavelengths have became an active and important part of the research on astronomy and also are the inspiration for observations at the other bands of the electromagnetic spectrum.

Radio Telescope System

The radio telescope system is the combination of the antenna system, the receiver and the recording equipment. The signals from the sky are collected by the antenna system and fed through the receiver by the cable. Since we are interested in the power of the electromagnetic wave emitted from the celestial object, we can detect the signal in the manner of an amplitude modulated (AM). The signal after detection have to amplified and fed through the recording system.

As in the previous description, there are many possible combinations which can be selected to accomplish. It depends on the frequency and the object in which we are interested.

The antenna system may be only a single antenna or an array. It's analogous to the lens or mirror of and optical telescope. Various types of antennae are used for radio astronomy purposes.

The signal is fed from the antenna system and we tune to the frequency of interest. From the radio-astronomy point of view, the receiver can be divided in two groups, "continuum" and "spectral-line" receivers. In the former, the exact frequency of operation is not critical, but for the latter the precise frequency of reception may be of paramount importance and may also need to be variable (Kraus, 1966).

The tuned signal is fed through the detection and integration circuit where the useful power value is extracted and amplified to be sufficient for the next stage.

The signal from the receiver may be displayed directly or store for the future processing. The storage media may be analog such as magnetic tapes or digital such as hard disks.The post data processing plays an important role for extracting the valuable information from a noisy and drifting system.

The post processing gives a chance to improve the signal-to-noise ratio by various techniques such as ensemble averaging. The processing of stored data prevents not only the irretrievable error from the processing but also permits the selection of parameters of detection such as integration time to the proper value. (Demas, 1990).

Due to the advance of the technology of electronics and computers, the highly powerful computer has already occupied a common place in the world of process and control, as well as in the field of radio astronomy.

The high speed digital computer and the large storage media for the post processing can improve more accurate information than the direct display. Moreover, some processes accomplished, such as the integration of the detected signal can be more reliably and stably by the digital processing than when using an common analog circuit. As discussed, it is a good decision to devise the equipment to acquire data to the computer and process with it.

Thesis purposes and confinements

This purpose of this thesis is to designed and construct the measuring equipment to complete the total power radio telescope system. The equipment are designed to provide the automatic data acquisition which is controlled by personal computer. The storage data will be effectively processed for extraction some physical quantities in radio astronomy by numerical methods. To accomplish such purpose, the basic concept of radio observation and signal processing have to be provided and the characteristic of the system have to be measured.

The system have to construct by the electrical component which is available commonly in our country. The celestial sources of observation is confined to the high intensity source such as the Sun. The transient signal from that source and the small change in the signal are neglected.